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ABSTRACT

New teaching methods and curricula that show promise in their ability to provide limited English proficient (LEP) students with a good education in both science and English are discussed and illustrated. Discriminatory practice has led to the clustering of LEP students into low ability tracks without consideration of their actual abilities and potential, resulting in underrepresentation of minorities in advanced mathematics and science classes. To stimulate children's intellectual development, school professionals must become familiar with the diverse backgrounds of their students to make instruction more meaningful. Science content taught to LEP students should be the same as that taught to other students. Furthermore, English language instruction must be an integral objective of all science instruction. Instructional techniques must emphasize development of thinking skills. Research has supported the effectiveness of cooperative learning for teaching science to LEP students. An inquiry/discovery approach is especially effective for LEP students. Innovations to improve science instruction for LEP students can best be implemented through teacher training, new curricula, parent involvement, and new approaches to assessment. A 22-item list of general references is supplemented by a list of 15 items related to instructional materials. (SLD)

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TEACHING SCIENCE EFFECTIVELY TO LIMITED ENGLISH PROFICIENT STUDENTS

A quality science education is essential to the future success of all students, as is proficiency in the English language. Since limited English proficient (LEP) students learn English skills most effectively when they are taught across the curriculum, it is especially productive to integrate science and English teaching. An integrated curriculum that teaches science in a way that is understandable and meaningful to multicultural students, as it promotes increased English language proficiency, can be developed for students at all educational levels, and does not require teachers with knowledge of the students' native languages.

While much of the science curricula currently in use is not effective for LEP students, new teaching methods and curricula are being developed that show great promise in their ability to provide students with a good education in both science and English. This digest discusses and provides examples of these innovations. It also presents two reference lists: one offers general references of use to teachers and administrators, the other includes specific examples of instructional materials for use with students.

Current Science Achievement Status of LEP Students

Schools with large Hispanic/LEP and other minority populations have habitually clustered these students into low ability tracks without consideration of their actual abilities or potential for academic success. The result of this discriminatory practice is the severe underrepresentation of minorities in advanced science and mathematics classes, and thus, in careers requiring advanced level science or math skills.

In fact, although the overall high school completion rate among all 25- to 29-year-olds was nearly 80 percent during the 1977-90 period, for Hispanics it was only 60 percent. During the same period, the number of Hispanics who received college degrees in the sciences, compared with other racial and ethnic groups, dropped significantly and continuously. Further, while African Americans and Hispanics constitute 10 and 7 percent of the total professional workforce, respectively, the representation of each group in the scientific workforce is only 2 percent. This disproportionate representation is damaging not only to the future well-being of the minorities denied science careers, but to the nation as a whole, which cannot afford to waste any available talent if all its technological needs are to be met.

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Early Science Education and English Language Development

Urban schools have a higher than average number of students with disadvantaged home environments that can compromise their ability to learn, and they also have large numbers of LEP students. A preschool science curriculum that includes English instruction can help young children overcome many obstacles to learning, however, and can prepare them for further effective schooling.

Such a curriculum must help young students make connections between their generation and those of the past for them to learn most successfully. Therefore, to best stimulate children's intellectual development, schools need to acquire a surer feel for contemporary cultural conditions. School professionals must become familiar with the diverse ethnic and cultural backgrounds of their students in order to draw on these differences to make instruction more meaningful and relevant. Below, a few examples of appropriate curricula are briefly described.

Experience with Plant and Animal Life. In particular, preschool students enjoy and learn from an environment that includes live animals and plants. They learn to respond to stimuli and to improve their language skills as they observe and handle living things, some of which may be an integral part of their native culture. Naturally motivated to describe, discuss, and compare plant and animal characteristics and behavior, nursery school children can readily overcome inhibitions to learning. They can also transfer the expanded knowledge of their own language gained through science activities to English. Moreover, experiences with description lay the groundwork for understanding the more abstract ideas presented in later science instruction.

Nutrition and Health Instruction. Learning about effective nutrition and health through the observation of the results of the various "diets" of living organisms increases young students' science knowledge as it encourages better eating habits. Simple experiments—such as demonstrating the variety of types of sugars in nature, not only the kind produced from cane—pique children's interest and provide information on the benefits (and costs) of eating certain categories of food. For students from homes where good nutrition is not stressed, knowledge about readily available, healthful, and inexpensive foods, if they act on it when they are able, can have a direct impact on their health, and, thus, on their ability to learn.

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K-12 Science Education and English Language Proficiency

At the elementary level, science, with its opportunities for hands-on experiences that allow students to see and feel the meaning of words instead of just hearing the definitions, is an excellent vehicle for second language development. In high school, proficiency in the language of instruction can be developed as science content is taught. Several premises are especially important to teaching science and English language skills simultaneously to LEP students:

Science content taught to LEP students should be the same as content taught to the other students. Science comprises the descriptions developed over time to explain how and why the environment operates as it does, and these understandings are universal, not more or less appropriate for members of certain cultures or races. In addition, universal access to an advanced science education is necessary to ensure equitable access to science career opportunities.

Cultural examples relevant to LEP students should be used to illustrate science content. An easy way to make science relevant to students is to point out the role it plays in their everyday lives. Explaining how water gets into their faucets and how heat gets into their radiators are two examples. Using students' own diets to explain the food chain and referring to agricultural practices in their native countries also personalize learning. Students should be encouraged to draw examples from their lives as a way of sharing information with students from different backgrounds, validating their own experiences, and learning to communicate in English.

In addition, it is important to point out language and other minority scientists who have made significant contributions to scientific knowledge in the U.S. Doing so promotes admiration by all students for the accomplishments of people of many different backgrounds. Equally important, it provides students who share the culture of the scientists with a role model and, thus, with the hope they, too, can have a successful career in science.

Science instruction is most effective when the content is organized around common themes. The themes can be broad science concepts such as the nature of matter or magnetic energy; or they can be societal issues such as the pollution and purification of water or the impact of drugs on the physiology and behavior of living organisms. This approach puts scientific knowledge in a comprehensible context with relevance to students' lives, which increases the probability that students will continue to want to learn science and language on their own; extends the time over which a single topic is studied, allowing more time for understanding and reflection, and for repetition in the use of the English vocabulary; and reduces the propensity to overcrowd the curriculum with complex content and vocabulary.

Effective instructional strategies for curricula based on themes include hands-on experience in a cooperative learning environment. In addition, multiple references are needed, rather than a single textbook, so students learn the value of investigating and comparing a variety of sources in order to learn, and are exposed to many types of writing and a larger English vocabulary.

English language development must be an integral objective of all science instruction. It is important to incorporate vocabulary development into science lessons both to ensure that students understand the science and to improve their English skills. Teachers should review the English terms or names to be used in a lesson before it is begun; help students label with stickers items to be used in an experiment; and verbally describe what they are doing, using language appropriate to the students' proficiency level. They should follow up by asking students to repeat the activity and describe it in their own words.

One way for students to develop English language skills is for them to carry out investigations within a group of students with varying levels of English proficiency, and to engage in follow through activities that motivate them to use English. Examples of such activities include writing summaries of the procedures used and results of their investigations, preparing a verbal presentation on it, and drawing a picture of it and explaining the picture in writing or verbally. Group activities include writing and producing a play, including English language prompt cards.

Many science trade books discuss specific topics or present biographies of scientists for students at all education and English proficiency levels. After students read these, teachers should lead a discussion, pose and ask for questions, and in general integrate promotion of English comprehension and language development with learning the content of the books.

Instructional Techniques

A major goal of science instruction is to develop students' ability to interpret and apply what they have learned. While simply memorizing facts can earn students good grades on standardized tests, and traditional teaching methods focus on providing students with those discrete facts, real learning requires the ability to understand, not just to repeat, course material. Thus, instructional techniques must stress development of thinking skills as well as acquisition of science information.

Group Instructional Classroom Organization. Research and experience have demonstrated that the classroom organization strategy most effective for teaching science to LEP students is cooperative learning because it fosters language development through inter-student (and possibly written) communication. In classrooms where LEP students have varying degrees of English language proficiency or come from different language backgrounds, the groups should reflect these variations as much as possible.

To assure maximum involvement of all students within each group, each student should be assigned a specific task (i.e., chief experimenter, observer, recorder, mathematician). Tasks should be rotated among the students from lesson to lesson to provide each student with the opportunity for varied contributions and experiences. If translators are needed, this role should be assigned to the students with proficiency in the primary language or in English. Students should be given ample opportunity to make choices and decisions, within the groups and personally, about how to organize their projects. They should be encouraged to evaluate their own work, to challenge each other's explanations and approaches within the group, and to discuss coursework with the teacher.

Inquiry/Discovery Instruction. In a discovery environment, students have the opportunity to find the answers to

the questions they themselves pose about a topic. They develop their English language skills as they articulate the problems they have devised and their efforts to solve them, and they learn to learn on their own. Students should also be given ample opportunities to test their own ideas. Ideally, teachers should provide a variety of resources to support students' discovery activities: materials for science laboratory investigations; reference books, newspapers and magazines, and access to libraries for additional materials; classroom visits from specialists in the community; field trips; films; and computer programs.

Lectures and demonstrations by teachers should be limited to use as summaries of what has been covered. They should not be used to convey new information because the purpose of the inquiry/discovery technique is for students to find out science information through their own efforts.

In order to provide students with the opportunity to think about and apply science concepts and to formulate complete thoughts in English, teachers should pose open-ended questions for them to answer. Assistance can take the form of providing references, helping students to use English to express their questions and answers; and helping them develop investigations that will lead to answers. Also, teachers should take care to use complete sentences, appropriate diction, and correct grammar. While this approach may result in coverage of less content, students will have a deeper understanding of the material that is covered, and will, ultimately, learn more because they learned not only some science concepts but also how to problem solve.

The inquiry/discovery method of science teaching is like the "whole or natural language" approach to teaching a new language. Whole language instruction deemphasizes pure memorization of language, stressing instead language skill development and comprehension through use of the language in a real world setting. Here, that setting is the science classroom.

It should be noted that the more traditional way of teaching science is the lecture/discussion method, where teachers "tell" the students what they are to learn, and then ask them to answer questions about what they heard, frequently providing the answers themselves if students don't respond quickly enough. This approach limits the learning experience for all students, for it gives them very little opportunity to discuss issues, solve problems, or ask their own questions, and, thus, to develop thinking skills. It is even less effective for LEP students since it is more dependent on students' understanding of what the teacher says, and it provides few occasions for students to speak, and, thus, practice their English skills.

Curriculum

As discussed above, curricula should help students understand the ways that science exists in their lives and promote English language proficiency. Coursework can expand students' learning potential in ways such as these:

Integrating Science and Mathematics Teaching. As students pose and solve science problems, they will naturally require use of mathematics, so combining instruction in both subjects, along with English language skills development, reinforces learning of each. It is especially important for students to use mathematics to answer questions arising from their coursework; solving math problems they themselves have created will help them better appreciate math's practical usefulness. Further, integration of science, mathematics, and English language learning obviates the need for the common and fragmented English as a Second Language or remedial math "pull-out" instruction that is less effective and stigmatizing for students.

Instructing with Computers. Science and mathematics learning is an excellent context for teaching the computer skills likely to be needed in the work world. Computers can simulate ideas that otherwise are very abstract and, thus, difficult to understand, and experiences and experiments too dangerous to engage in firsthand or requiring unavailable resources. Computers should not be used to substitute totally for hands-on experiences, however, for students need to see at least some science in action for it to be meaningful to them. Moreover, research has shown that computer instruction is most effective after students have had some real experiences.

Implementing the Innovations

Teacher Training. Since most teachers are educated to use the lecture/discussion instructional method, to help them switch to an emphasis on inquiry/discovery, they should be provided with inservice training, and, perhaps, with mentors who are already skilled in the method. The National Science Foundation is supporting training and enhancement programs to help teachers master the method.

Curriculum. New curriculum materials based on the inquiry/discovery method are currently being developed, some with support from the National Science Foundation. Old curricula should be reviewed to determine whether the English language readability level is too high for LEP students, and revised as necessary.

Parent Involvement. Additional parent involvement may be required as parents are asked to provide materials and references at home, and to accompany their children's classes on field trips.

Assessment. A substantial effort to revise approaches to assessing students is underway nationally, for reasons that include bias in traditional assessments against LEP and other minority students. Traditionally, multiple choice standardized tests and poorly constructed classroom tests have measured students' ability to memorize science facts rather than their ability to understand and apply them. LEP students usually receive low scores on such tests, and, as a result, they are unlikely to continue their science education. Thus, use of testing as a "gatekeeper" to determine which students are permitted to pursue advanced science studies must be eliminated if LEP students are to have such access.

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